JC03 Rec'd PCT/PTO 24 OCT 2001

FORM PTO-1390 (REV. 11-2000) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER 32860-000191
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/980692
INTERNATIONAL APPLICATION NO. PCTDE00/01035	INTERNATIONAL FILING DATE April 4, 2000	PRIORITY DATE CLAIMED April 27, 1999

TITLE OF INVENTION
METHOD AND ARRANGEMENT FOR DESIGNING A TECHNICAL SYSTEM

APPLICANT(S) FOR DO/EO/US
Annelie STOEHR

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39 (1).
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau). WO 00/65412
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is transmitted herewith.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4)
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 20. below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98-1449 and International Search Report (PCT/ISA/210) in German with NINE (9) references.
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☒ A substitute specification.
16. ☒ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information:

JC10 Rec'd PCT/PTO 2 4 OCT 2001

U.S. APPLICATION NO (if known, see 37 CFR 1 5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
09/980692	PCTDE00/01035	32860-000191

21. ☒ The following fees are submitted:

	CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5): Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO . . . . **$1,040.00** International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO . . . . **$890.00** International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO. . . . . **$710.00** International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) . . . . **$690.00** International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4). **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	46 - 20 =	26	X **$18.00**	$ 468.00	
Independent Claims	2 - 3 =		X **$80.00**	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$270.00**	$	
TOTAL OF ABOVE CALCULATIONS =				$ 1,358.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				$	
SUBTOTAL =				$	
Processing fee of **$130.00** for furnishing the English translation later than ☐20 ☐30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$ 1,358.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ 40.00	
TOTAL FEES ENCLOSED =				$ 1,398.00	
				Amount to be: refunded	$
				charged	$

a. ☐ A check in the amount of $ _____ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account. No. 08-0750 in the amount of $1,398.00 to cover the above fees. A triplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 08-0750.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

Send all correspondence to:
Harness, Dickey & Pierce, P.L.C – Customer No. 30596
Post Office Box 8910
Reston, Virginia 20195

Date: October 24, 2001

By [signature]
Donald J. Daley, #34,313

/kna

BOX PCT
PATENT
32860-000191

IN THE U.S. PATENT AND TRADEMARK OFFICE

Applicants: Annelie STOEHR

Application No.: **NEW**

Filed: October 24, 2001

For: METHOD AND ARRANGEMENT FOR DESIGNING A TECHNICAL SYSTEM

PRELIMINARY AMENDMENT

BOX PCT
Assistant Commissioner for Patents
Washington, DC 20231

October 24, 2001

Sir:

The following preliminary amendments and remarks are respectfully submitted in connection with the above-identified application.

IN THE ABSTRACT OF THE DISCLOSURE

Please replace the original Abstract with the attached revised Abstract.

IN THE SPECIFICATION

Please replace the Specification with the attached Substitute Specification attached hereto.

IN THE CLAIMS

Please amend the claims as follows:

1. (Amended) A method for designing a technical system, comprising:

providing a target function of the technical system, influenced by a parameter vector including a plurality of parameters;

providing secondary conditions of the technical system to determine a domain for valid working points of the technical system;

determining a Stratonovich equation using a projection operator;

solving the Stratonovich equation numerically, and thereby determining an efficient working point; and

using the determined efficient working point to design the technical system.

2. (Amended) The method as claimed in claim 1, wherein the Stratonovich equation is determined such that its solution varies in a domain of valid working points.

3. (Amended) The method as claimed in claim 1, wherein the Stratonovich equation is solved numerically by a predictor-corrector method.

4. (Amended) The method as claimed in claim 3, wherein the predictor is determined with the aid of a trapezium rule.

5. (Amended) The method as claimed in claim 3, wherein the corrector is determined by a Newton method.

6. (Amended) The method as claimed in claim 1, further comprising:

additionally performing step size control.

7. (Amended) The method as claimed in claim 6, wherein the performance of the step size control includes at least one of,

carrying out a step size reduction if a sufficiently large approximation error is determined, and

carrying out a step size enlargement if a sufficiently small approximation error is determined.

8. (Amended) The method as claimed in claim 1, wherein the Stratonovich equation has the following form:

$$X_t = X_a - \int_a^t P(X_s) \cdot F(X_s) \cdot ds + Z, \text{ wherein } t \geq a \text{ and } X_a = x_0,$$

and wherein,

a	denotes a starting instant ($a \geq 0$),
x_0	denotes a permissible starting parameter vector,
X_t	denotes a solution parameter vector at the instant t,
$P(X_s)$	denotes a projection matrix in the parameter vector X_s,
$F(X_s)$	denotes an ascending direction, and
Z	denotes a random variable.

9. (Amended) The method as claimed in claim 8, wherein the ascending direction is determined by:

$$F = \nabla f(X_s),$$

wherein, f denotes the target function.

10. (Amended) The method as claimed in claim 8, wherein the random variable is determined by

$$Z = \varepsilon \cdot \int_a^t P(X_s) \circ dB_s,$$

wherein,

ε	denotes a scaling factor, and
$\{B_s: s \geq a\}$	denotes an n-dimensional Brownian movement.

11. (Amended) The method as claimed in claim 1, further comprising:

using the determined working point as a starting point for a local optimization method.

12. (Amended) The method as claimed in claim 1, further comprising:

transforming a secondary condition which is present in the form of an inequality, into an equation using a slack variable s.

13. (Amended) The method as claimed in claim 12, wherein the secondary condition $h_i(x)$, which is present in the form of the inequality $h_i(x) \leq 0$, is formulated as

$$\tilde{h}_i(x, s) = h_i(x) + g(s),$$

wherein,

g(s) denotes a function including a value range of all real values greater than or equal to zero,

s denotes the slack variable, and

$h_i(x)$ denotes a secondary condition $h_i(x) \leq 0$.

14. (Amended) The method as claimed in claim 13, wherein the function g(s) is determined as

$$g(s) = s^2.$$

15. (Amended) The method as claimed in claim 1, wherein the design is at least one of a new design, an adaptation and a control of the technical system.

16. (Amended) An arrangement for designing a technical system, comprising:

a processor unit set up to perform the various steps wherein, the technical

system includes a target function which can be influenced by a parameter vector including a plurality of parameters and secondary conditions of the technical system are used to determine a domain for valid working points of the technical system, the processor unit being set up to,

determine a Stratonovich equation using a projection operator;

solve the Stratonovich equation numerically and thereby determine an efficient working point; and

use the determined efficient working point to design the technical system.

Please add the following new claims:

17. The method of claim 1, wherein the secondary conditions are associated with the target function.

18. The arrangement of claim 16, wherein the secondary conditions are associated with the target function.

19. The method as claimed in claim 2, wherein the Stratonovich equation is solved numerically by a predictor-corrector method.

20. The method as claimed in claim 4, wherein the corrector is determined by a Newton method.

21. The method as claimed in claim 2, further comprising:

additionally performing step size control.

22. The method as claimed in claim 21, wherein the performance of the step size control includes at least one of,

carrying out a step size reduction if a sufficiently large approximation error is determined, and

carrying out a step size enlargement if a sufficiently small approximation error is determined.

23. The method as claimed in claim 2, wherein the Stratonovich equation has the following form:

$$X_t = X_a - \int_a^t P(X_s) \cdot F(X_s) \cdot ds + Z, \text{ wherein } t \geq a \text{ and } X_a = x_o,$$

and wherein,

a	denotes a starting instant ($a \geq 0$),
x_0	denotes a permissible starting parameter vector,
X_t	denotes a solution parameter vector at the instant t,
$P(X_s)$	denotes a projection matrix in the parameter vector X_s,
$F(X_s)$	denotes an ascending direction, and
Z	denotes a random variable.

24. The method as claimed in claim 23, wherein the ascending direction is determined by:

$$F = \nabla f(X_s),$$

wherein, f denotes the target function.

25. The method as claimed in claim 9, wherein the random variable is determined by

$$Z = \varepsilon \cdot \int_a^t P(X_s) \circ dB_s,$$

wherein,

ε denotes a scaling factor, and

$\{B_s: s \geq a\}$ denotes an n-dimensional Brownian movement.

26. The method as claimed in claim 23, wherein the random variable is determined by

$$Z = \varepsilon \cdot \int_a^t P(X_s) \circ dB_s,$$

wherein,

ε denotes a scaling factor, and

$\{B_s: s \geq a\}$ denotes an n-dimensional Brownian movement.

27. The method as claimed in claim 24, wherein the random variable is determined by

$$Z = \varepsilon \cdot \int_a^t P(X_s) \circ dB_s,$$

wherein,

ε denotes a scaling factor, and

$\{B_s: s \geq a\}$ denotes an n-dimensional Brownian movement.

28. The method as claimed in claim 2, further comprising:

using the determined working point as a starting point for a local optimization method.

29. The method as claimed in claim 2, further comprising:

transforming a secondary condition which is present in the form of an inequality, into an equation using a slack variable s.

30. The method as claimed in claim 29, wherein the secondary condition $h_i(x)$, which is present in the form of the inequality $h_i(x) \leq 0$, is formulated as

$$\tilde{h}_i(x, s) = h_i(x) + g(s),$$

wherein,

g(s) denotes a function including a value range of all real values greater than or equal to zero,

s denotes the slack variable, and

$h_i(x)$ denotes a secondary condition $h_i(x) \leq 0$.

31. The method as claimed in claim 30, wherein the function g(s) is determined as

$g(s) = s^2$.

32. The method as claimed in claim 2, wherein the design is at least one of a new design, an adaptation and a control of the technical system.

33. The arrangement of claim 16, wherein the processor unit includes,

a central processor;

a memory; and

an input and output unit.

34. The arrangement as claimed in claim 16, wherein the Stratonovich equation is determined such that its solution varies in a domain of valid working points.

35. The arrangement as claimed in claim 16, wherein the Stratonovich equation is solved numerically by a predictor-corrector method.

36. The arrangement as claimed in claim 35, wherein the predictor is determined with the aid of a trapezium rule.

37. The arrangement as claimed in claim 16, wherein the Stratonovich equation has the following form:

$$X_t = X_a - \int_a^t P(X_s) \cdot F(X_s) \cdot ds + Z, \text{ wherein } t \geq a \text{ and } X_a = x_o,$$

and wherein,

a denotes a starting instant ($a \geq 0$),

x_0 denotes a permissible starting parameter vector,

X_t denotes a solution parameter vector at the instant t,

$P(X_s)$ denotes a projection matrix in the parameter vector X_s,

$F(X_s)$ denotes an ascending direction, and

Z denotes a random variable.

38. The arrangement as claimed in claim 37, wherein the ascending direction is determined by:

$$F = \nabla f(X_s),$$

wherein, f denotes the target function.

39. The arrangement as claimed in claim 37, wherein the random variable is determined by

$$Z = \varepsilon \cdot \int_a^t P(X_s) \circ dB_s,$$

wherein,

ε denotes a scaling factor, and

$\{B_s: s \geq a\}$ denotes an n-dimensional Brownian movement.

40. The arrangement as claimed in claim 16, wherein the design is at least one of a new design, an adaptation and a control of the technical system.

41. The method of claim 1, wherein the projection operator takes account of the secondary conditions.

42. The method of claim 17, wherein the projection operator takes account of the secondary conditions.

43. The arrangement of claim 16, wherein the projection operator takes account of the secondary conditions.

44. The arrangement of claim 18, wherein the projection operator takes account of the secondary conditions.

45. The method of claim 1, wherein the efficient working point is an optimum working point.

46. The arrangement of claim 1, wherein the efficient working point is an optimum working point. --

REMARKS

Claims 1-46 are now present in this application, with new claims 17-46 being added by the present Preliminary Amendment. It should be noted that the amendments to original claims 1-16 of the present application are non-narrowing amendments, made solely to place the claims in proper form for U.S. practice and not to overcome any prior art or for any other statutory considerations. For example, amendments have been made to broaden the claims; remove reference numerals in the claims; remove the European phrase "characterized in that"; remove multiple dependencies in the claims; and to place claims in a more recognizable U.S.

form, including the use of the transitional phrase "comprising" as well as the phrase "wherein". Other such non-narrowing amendments include changing the phrase "or" to --at least one of--, and reorganizing method (using separate clauses beginning with "-ing" verbs) and apparatus-type claims (setting forth elements in separate paragraphs and re-ordering elements) in a more recognizable U.S. form. Again, all amendments are non-narrowing and have been made solely to place the claims in proper form for U.S. practice and not to overcome any prior art or for any other statutory considerations.

SUBSTITUTE SPECIFICATION

In accordance with 37 C.F.R. §1.125, a substitute specification has been included in lieu of substitute paragraphs in connection with the present Preliminary Amendment. The substitute specification is submitted in clean form, attached hereto, and is accompanied by a marked-up version showing the changes made to the original specification. The changes have been made in an effort to place the specification in better form for U.S. practice. No new matter has been added by these changes to the specification. Further, the substitute specification includes paragraph numbers to facilitate amendment practice as requested by the U.S. Patent and Trademark Office.

CONCLUSION

Accordingly, in view of the above amendments and remarks, an early indication of the allowability of each of claims 1-46 in connection with the present application is earnestly solicited.

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact Donald J. Daley at the telephone number of the undersigned below.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 08-0750 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

HARNESS, DICKEY & PIERCE, P.L.C

By:

Donald J. Daley, Reg. No. 34,313

P.O. Box 8910
Reston, Virginia 20195
(703) 390-3030

DJD:kna

ABSTRACT OF THE DISCLOSURE

A method for designing a technical system is specified in the case of which the technical system includes a target function which is influenced by a parameter vector having n parameters. Furthermore, secondary conditions are prescribed with the aid of which a domain for valid working points of the technical system is determined. An efficient working point is determined using a Stratonovich equation and is used to design the technical system.

SUBSTITUTE SPECIFICATION

METHOD AND ARRANGEMENT FOR DESIGNING A TECHNICAL SYSTEM

[001] This application is the national phase under 35 U.S.C. § 371 of PCT International Application No. PCT/DE00/01035 which has an International filing date of April 4, 2000, which designated the United States of America, the entire contents of which are hereby incorporated by reference.

Field of the Invention

[002] The invention generally relates to a method and an arrangement for designing a technical system.

Background of the Invention

[003] In order to design a complex technical system, it is necessary to determine among a set of permissible working points (operating points, design parameters) at least one working point which permits effective running of the system. This frequently requires taking account of secondary conditions which limit the set of working points and therefore also need to be taken into account when searching for the working point.

[004] In practice, the technical system is frequently designed with the aid of experience and the knowledge of one (or more) expert. It is disadvantageous in this case that the probability of error in the case of manual design rises when a certain complexity of the technical system is exceeded.

[005] A method for optimization which follows an approach with the aid of which global optimization is carried out on the basis of a numerical solution of a stochastic differential equation is known from reference [1], listed at the end of the application and incorporated herein by reference. Secondary conditions are taken into account in this case as penalty functions. It is disadvantageous in this case that the range of permissible working points is left because

a) information is thereby lost,
b) permissibility is frequently more important than quality in a technical system, or it is not even possible to operate the system in an impermissible range, and
c) penalty functions are difficult to prescribe or to dimension in practical use.

[006] Reference [2] describes a method for local optimization under secondary conditions with the aid of projections, in the case of which nonlinear secondary conditions, in particular, are taken into account.

[007] The concept of a Stratonovich equation (also: "Fisk-Stratonovich equation") is known

from reference [3]. In this case, the Stratonovich equation denotes a type of stochastic differential equations with specific (see reference [3]) properties.

SUMMARY OF THE INVENTION

[008] An object of the invention is directed to permitting a design of a technical system which manages without separate penalty functions.

[009] This object is achieved, for example, in accordance with the features of the independent patent claims. Developments of the invention follow from the dependent claims.

[0010] In order to achieve the object, for example, a method for designing a technical system is specified in which the technical system comprises a target function which is influenced by a parameter vector having n parameters. Secondary conditions are prescribed with the aid of which a domain for valid working points of the technical system is determined. A projection operator is used to determine a Stratonovich equation which is solved numerically to determine an efficient working point. The determined efficient working point is used to design the technical system.

[0011] As a development, the Stratonovich equation is determined in such a way that its solution varies in the domain of the valid working points.

[0012] Another development is that the Stratonovich equation is solved numerically by way of a predictor-corrector method. A predictor can generally be described as a prediction variable which has, relative to the variable, to be predicted an error which is largely compensated by way of the corrector.

[0013] In particular, the predictor can be determined with the aid of the trapezium rule. In this context, the trapezium rule for Riemann integrals is known, for example, from reference [4]. The trapezium rule for Stratonovich integrals follows from the definition of the Stratonovich integral itself. Thus, the Stratonovich integral is defined as a limiting value of the trapezium sums, and so the trapezium rule is a part of the definition of the Stratonovich integral. Trapezium sums are used to set up for the predictor an implicit equation which is solved approximately with the aid of a Newton method.

[0014] One refinement resides in that step size control is additionally performed in the course of the global optimization. This takes place, in particular, by way of step size reduction if an excessively large approximation error is expected (value for the expected approximation error exceeds a prescribed bound), or by way of step size enlargement if a (very) small approximation error is expected (value for the expected approximation error is below a prescribed bound).

[0015] It is also possible to carry out an additional step size reduction if an efficient working point determined using the above described method is used as a starting value for a subsequent local optimization method. It can be ensured thereby that an approximation with an increasingly smaller step size is performed in the vicinity of the local optimum, and the

optimum is achieved with high accuracy thereby.

[0016] Another refinement resides in that the Stratonovich equation has the following form, in particular:

$$X_t = X_a - \int_a^t P(X_s) \cdot F(X_s) \cdot ds + Z \qquad (1)$$

with $t \geq a$ and $X_a = x_o$

where

a	denotes a starting instant ($a \geq 0$),
x_0	denotes a permissible starting parameter vector,
X_t	denotes a solution parameter vector at the instant t,
$P(X_s)$	denotes a projection matrix in the parameter vector X_s,
$F(X_s)$	denotes an ascending direction in the parameter vector X_s,
Z	denotes a random variable.

[0017] Furthermore, the ascending direction can be determined by

$$F = \nabla f(X_s), \qquad (2),$$

where f denotes the target function.

[0018] In an additional refinement, the random variable Z is determined by

$$Z = \varepsilon \cdot \int_a^t P(X_s) \circ dB_s \qquad (3),$$

where

ε	denotes a scaling factor, and
$\{B_s: s \geq a\}$	denotes an n-dimensional Brownian movement.

[0019] It is known from reference [5] that a numerical solution of the stochastic differential equation

$$X_t = X_a \int_a^t \nabla f(X_s)\, ds + \varepsilon \cdot \int_a^t dB_s,\ t \geq a \qquad (4)$$

with an arbitrary starting parameter vector $x_0 \varepsilon \mathbf{R}^n$ (with **R** as the set of real numbers) and the starting condition $X_a = x_o$ resulting therefrom results in a method for global optimization of f in the parameter space.

[0020] If, in addition, secondary conditions are present in the form of equations and inequalities which limit the parameter space, the permissible parameter space is, in particular, initially reformulated, by way of introducing slack variables, such that it describes a manifold. In the above differential equation (4), it is only those components of the integrand which run tangential to the manifold that are taken into account. This is performed by multiplying by projection matrices. The result is the particular stochastic differential equation according to equation (1) (in particular seen in conjunction with equations (2) and (3), which is of the type of a Stratonovich differential equation.

[0021] An additional development resides in that a secondary condition $h_i(x) \leq 0$ which is present in the form of an inequality is transformed into an equation by way of a slack variable. This transformation has the form, in particular, of

$$\tilde{h}_i(x, s) = h_i(x) + g(s),$$

where

g(s) denotes a function having a value range of all real values greater than or equal to zero (R_0^+),

s denotes the slack variable, and

h_i(x denotes a secondary condition $h_i(x) \leq 0$.

[0022] Furthermore, the function g(s) can be determined as:

$$g(s) = s^2 \qquad (6).$$

[0023] The solution of the equation (1) is a stochastic process

$$\{X_t : t \geq a\} \qquad (7)$$

[0024] A sequence of permissible parameter vectors

$$x_{t_1}, x_{t_2}, x_{t_3}, \ldots \quad (a < t_1 < t_2 < t_3 \ldots) \qquad (8)$$

is calculated which approximately represent points of a path of the stochastic process in accordance with the equation (7) at the instances t_1, t_2, t_3, ... An iteration step comes about in this case in the following way: let the parameter vectors $x_{t_1}, x_{t_2}, x_{t_3}, \ldots, x_{t_i}$ be already calculated, in which case x_{t_i} then serves as starting point for the Stratonovich equation (1),

that is to say a: =t_i. A parameter vector $x_{t_{i+1}}$ is calculated as a numerical approximation of a point on the path of the solution in accordance with equation (7), which already includes the points $x_{t_1}, x_{t_2}, x_{t_3}, \ldots, x_{t_i}$. The calculation is performed at the instant t_{i+1}, that is to say $t = t_{i+1}$, and the size of the iteration step is yielded as $t_{i+1} - t_i$.

[0025] A subset of the sequence (8), in particular that with the smallest target function values, serves the purpose of determining the starting points for a subsequent local search for the optimum.

[0026] The approximation of the Stratonovich equation (1) is performed for the (i+1)th iteration step using the following rule (with the aid of the trapezium rule):

$$\begin{aligned} x_{t_{i+1}} \approx\ & x_{t_i} \\ & - \frac{t_{i+1} - t_i}{2} \left(P\left(x_{t_i}\right) \cdot \nabla f\left(x_{t_i}\right) + P\left(x_{t_{i+1}}\right) \cdot \nabla f\left(x_{t_{i+1}}\right) \right) \\ & + \frac{\varepsilon}{2} \left(P\left(x_{t_i}\right) + P\left(x_{t_{i+1}}\right) \right) \cdot \left(B_{t_{i+1}} - B_{t_i} \right) \end{aligned} \tag{9}$$

[0027] Equation (9) is an implicit equation for the random variable $x_{t_{i+1}}$. An approximation $y_{t_{i+1}}$ for a realization of the random variable $x_{t_{i+1}}$ can be determined therefrom with the aid of the Newton method.

[0028] The point $y_{t_{i+1}}$ is impermissible in some circumstances. With the aid of a Newton method, the corrector is now used to determine a point $x_{t_{i+1}}$ in the vicinity of the point $y_{t_{i+1}}$ which is permissible and serves as starting value for a subsequent iteration step.

[0029] Another refinement resides in that the design constitutes a new design, an adaptation or a control of the technical system.

[0030] For a successful design, values which are efficient in each case are determined for the parameter vector and the working point. An efficient valuation of the parameter vector means that no parameter can be changed without thereby worsening a Q factor of the target function.

[0031] A technical system can be a process engineering installation or other system which is to be designed or adjusted with reference to various parameters. In particular, the parameters of the parameter vector can be design parameters or operating parameters of the technical

system. Operating parameters characterize possible adjustable variables, whereas design parameters describe, in particular, physical dimensions of the technical system and can be adapted or varied during operation mostly only with a high outlay.

[0032] The method described can optionally be used to redesign the technical system or to adapt an already existing technical system. In both cases, this is a design (once as regeneration and once as adaptation) within the meaning of the present discussion.

[0033] The technical system is realized or adjusted with the aid of the determined parameters within the scope of a further refinement. It is advantageous in this case that the parameters in a parameter vector which have been determined by the invention characterize a stable operating point, and that the adjustment of the system to this operating point ensures long-term reliable operation of the system/installation.

[0034] To better achieve the object, moreover, an arrangement is specified for designing a technical system in the case of which a processor unit is provided which is set up in such a way that

a) the technical system comprises a target function which can be influenced by a parameter vector having n parameters;
b) secondary conditions are prescribed with the aid of which a domain for valid working points of the technical system can be determined;
c) a Stratonovich equation is determined by means of a projection operator;
d) the Stratonovich equation can be solved numerically and an efficient working point can be determined thereby;
e) the efficient working point can be used to design the technical system.

[0035] This arrangement is particularly suitable for carrying out the method according to the invention or one of its developments explained above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] Exemplary embodiments of the invention are set forth and explained below with the aid of the drawing, in which:

Figure 1 shows a sequence of operations of a method for designing a technical system;

Figure 2 shows a sketch which illustrates a numerical solution of a Stratonovich differential equation;

Figure 3 shows a sketch which illustrates a projection method;

Figure 4 shows a processor unit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0037] **Figure 1** shows a block diagram which illustrates the sequence of operations of a method for designing a technical system. A target function and associated secondary conditions are provided in a block 101. The secondary conditions limit a space, which is determined by the number of the n parameters of the parameter vector, to a domain as part of this space. An efficient working point from this domain is determined as parameter vector by setting up and solving a Stratonovich equation by using projection operators which take account of the secondary conditions (compare blocks 102 and 103). Some of the working points found serve as starting points for a local search which, in turn, delivers an optimum point (efficient working point) (see block 104). In particular, the numerical solution to the Stratonovich equation includes a predictor-corrector method.

[0038] **Figure 2** illustrates the predictor-corrector method. Starting from a point x_{t_i} which is located in the permissible working range L, a point $y_{t_{i+1}}$ is determined (application of the Newton method to equation (9), for example) which is no longer situated in the permissible range L (predictor step 201). In order to transfer the point $y_{t_{i+1}}$ into the permissible range again, a correction step 202 is determined which leads to the point $x_{t_{i+1}}$.

[0039] The interplay between predictor and corrector is repeated iteratively with a constant, decreasing or increasing step size. It may be noted in this case that the line 201 does not necessarily run tangentially.

[0040] **Figure 3** illustrates the projection method. Once again, the permissible range L is specified on which the point $x_{t_{i+1}}$ is located. The line 203 characterizes an ascending direction $F(X_t)$, and a line 204 indicates a projected ascending direction $P(X_t) \cdot F(X_t)$.

[0041] An example processor unit PRZE is illustrated in **Figure 4**. The processor unit PRZE includes a processor CPU, a memory MEM and an input/output interface IOS, which is used via an interface IFC in different ways: via a graphics interface, an output is visualized on a monitor MON and/or output on a printer PRT and/or output to any other type of output device. An input is performed via a mouse MAS and/or a keyboard TAST and/or any other type of input device. The processor unit PRZE also includes a data bus BUS which ensures the connection of a memory MEM, the processor CPU and the input/output interface IOS. Additional components, for example an additional memory, data memory (hard disk), scanner, etc., can also be connected to the data bus BUS.

[0042] The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of

the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

[0043] List of references, the entire contents of each of which is hereby incorporated herein by reference:

[1] K. Ritter, S. Schäffler: "A Stochastic Method for Constrained Global Optimization", SIAM 3. Optimization, Vol. 4, No. 4, pp. 894-904, 1994.

[2] D.G. Luenberger: "Linear and Nonlinear Programming", Addison-Wesley Publishing Company, Massachusetts, pp. 334-337.

[3] P. Protter: "Stochastic Integration and Differential Equations - A New Approach", Springer Verlag, New York, pp. 215-235.

[4] J. Stoer: "Numerische Mathematik 1" ["Numerical Mathematics 1"], Springer-Verlag, Berlin, Heidelberg, 1994, pp. 138-144.

[5] S. Schäffer: "Global Optimization Using Stochastic Integration"; Theorie und Forschung, Vol. 340: Mathematik, Vol. 3; Regensburg: Roderer, 1994; ISBN 3-89073-0; pp. 19-29.

09/980692

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GR 99 P 1730

Description

Method and arrangement for designing a technical system

FIELD OF THE INVENTION

The invention generally relates to a method and an arrangement for designing a technical system.

BACKGROUND OF THE INVENTION

In order to design a complex technical system, it is necessary to determine among a set of permissible working points (operating points, design parameters), at least one working point which permits effective running of the system. This frequently requires taking account of secondary conditions which limit the set of working points and therefore also need to be taken into account when searching for the working point.

In practice, the technical system is frequently designed with the aid of experience and the knowledge of ~~or~~ one (or more) expert. It is disadvantageous in this case that the probability of error in the case of manual design rises when a certain complexity of the technical system is exceeded.

A method for optimization which follows an approach with the aid of which global optimization is carried out on the basis of a numerical solution of a stochastic differential equation is known from reference [1], listed at the end of the application and incorporated herein by reference. Secondary conditions are taken into account in this case as penalty functions. It is disadvantageous in this case that the range of permissible working points is left because:

a) information is thereby lost,
b) permissibility is frequently more important than quality in a technical system, or it is not even possible to operate the system in an impermissible range, and
c) penalty functions are difficult to prescribe or to dimension in practical use.

Reference [2] describes a method for local optimization under secondary conditions with the aid of projections, in the case of which nonlinear secondary conditions, in particular, are taken into account.

The concept of a Stratonovich equation (also: "Fisk-Stratonovich equation") is known from reference [3]. In this case, the Stratonovich equation denotes a type of stochastic differential equations with specific (see reference [3]) properties.

SUMMARY OF THE INVENTION

~~The **object**~~ An object of the invention ~~consists in~~ is directed to permitting a design of a technical system which manages without separate penalty functions.

This object is achieved, for example, in accordance with the features of the independent patent claims. Developments of the invention follow from the dependent claims.

In order to achieve the object, for example, a method for designing a technical system is specified in which the technical system comprises a target function which is influenced by a parameter vector having n parameters. Secondary conditions are prescribed with the aid of which a domain for valid working points of the technical system is determined. A projection operator is used to determine a Stratonovich equation which is solved numerically to determine an efficient working point. The determined efficient working point is used to design the technical system.

As a development, the Stratonovich equation is determined in such a way that its solution varies in the domain of the valid working points.

Another development ~~consists in~~ is that the Stratonovich equation is solved numerically by ~~means~~ way of a predictor-corrector method. A predictor can generally be described

as a prediction variable which has, relative to the variable, to be predicted an error which is largely compensated by ~~means~~ way of the corrector.

In particular, the predictor can be determined with the aid of the trapezium rule. In this context, the trapezium rule for Riemann integrals is known, for example, from reference [4]. The trapezium rule for Stratonovich integrals follows from the definition of the Stratonovich integral itself. Thus, the Stratonovich integral is defined as a limiting value of the trapezium sums, and so the trapezium rule is a part of the definition of the Stratonovich integral. Trapezium sums are used to set up for the predictor an implicit equation which is solved approximately with the aid of a Newton method.

One refinement ~~consists~~ resides in that step size control is additionally performed in the course of the global optimization. This takes place, in particular, by ~~means~~ way of step size reduction if an excessively large approximation error is expected (value for the expected approximation error exceeds a prescribed bound), or by ~~means~~ way of step size enlargement if a (very) small approximation error is expected (value for the expected approximation error is below a prescribed bound).

It is also possible to carry out an additional step size reduction if an efficient working point determined using the above described method is used as a starting value for a subsequent local optimization method. It can be ensured thereby that an approximation with an increasingly smaller step size is performed in the vicinity of the local optimum, and the optimum is achieved with high accuracy thereby.

Another refinement ~~consists~~ resides in that the Stratonovich equation has the following form, in particular:

$$X_t = X_a - \int_a^t P(X_s) \cdot F(X_s) \cdot ds + Z \qquad (1)$$

with $t \geq a$ and $X_a = x_o$

where

a denotes a starting instant ($a \geq 0$),

x_0 denotes a permissible starting parameter vector,

X_t denotes a solution parameter vector at the instant t,

$P(X_s)$ denotes a projection matrix in the parameter vector X_s,

$F(X_s)$ denotes an ascending direction in the parameter vector X_s,

Z denotes a random variable.

Furthermore, the ascending direction can be determined by

$$F = \nabla f(X_s), \qquad (2),$$

where f denotes the target function.

In an additional refinement, the random variable Z is determined by

$$Z = \varepsilon \cdot \int_a^t P(X_s) \circ dB_s \qquad (3),$$

where

ε denotes a scaling factor, and

$\{B_s: s \geq a\}$ denotes an n-dimensional Brownian movement.

It is known from reference [5] that a numerical solution of the stochastic differential equation

$$X_t = X_a \int_a^t \nabla f(X_s) ds + \varepsilon \cdot \int_a^t dB_S, \ t \geq a \qquad (4)$$

with an arbitrary starting parameter vector $x_0 \varepsilon \mathbf{R}^n$ (with **R** as the set of real numbers) and the starting condition $X_a = x_0$ resulting therefrom ~~constitutes~~ results in a method for global optimization of f in the parameter space.

If, in addition, secondary conditions are present in the form of equations and inequalities which limit the parameter space, the permissible parameter space is, in particular, initially reformulated, by ~~means~~ way of introducing slack variables, such that it describes a manifold. In the above differential equation (4), it is only those components of the integrand which run tangential to the manifold that are taken into account. This is performed by multiplying by projection matrices. The result is the particular stochastic differential equation according to equation (1) (in particular seen in conjunction with equations (2) and (3), which is of the type of a Stratonovich differential equation.

An additional development ~~consists~~ resides in that a secondary condition $h_i(x) \leq 0$ which is present in the form of an inequality is transformed into an equation by means of a slack variable. This transformation has the form, in particular, of

$$\tilde{h}_i(x, s) = h_i(x) + g(s),$$

where

g(s) denotes a function having a value range of all real values greater than or equal to zero (R_0^+),

s denotes the slack variable, and

$h_i(x$ denotes a secondary condition $h_i(x) \leq 0$.

Furthermore, the function g(s) can be determined as:

$$g(s) = s^2 \qquad (6).$$

The solution of the equation (1) is ~~constitutes~~ a stochastic process

$$\{X_t : t \geq a\} \qquad (7)$$

A sequence of permissible parameter vectors

$$x_{t_1}, x_{t_2}, x_{t_3}, \ldots \quad (a < t_1 < t_2 < t_3 \ldots) \qquad (8)$$

is calculated which approximately represent points of a path of the stochastic process in accordance with the equation (7) at the instances t_1, t_2, t_3, ... An iteration step comes about in this case in the following way: let the parameter vectors $x_{t_1}, x_{t_2}, x_{t_3}, \ldots, x_{t_i}$ be already calculated, in which case x_{t_i} then serves as starting point for the Stratonovich equation (1), that is to say $a := t_i$. A parameter vector $x_{t_{i+1}}$ is calculated as a numerical approximation of a point on the path of the solution in accordance with equation (7), which already includes the points $x_{t_1}, x_{t_2}, x_{t_3}, \ldots, x_{t_i}$. The calculation is performed at the instant t_{i+1}, that is to say $t = t_{i+1}$, and the size of the iteration step is yielded as $t_{i+1} - t_i$.

A subset of the sequence (8), in particular that with the smallest target function values, serves the purpose of determining the starting points for a subsequent local search for the optimum.

The approximation of the Stratonovich equation (1) is performed for the (i+1)th iteration step using the following rule (with the aid of the trapezium rule):

$$
\begin{aligned}
X_{t_{i+1}} \approx\ & x_{t_i} \\
& - \frac{t_{i+1} - t_i}{2}\Big(P\big(x_{t_i}\big)\cdot \nabla f\big(x_{t_i}\big) + P\big(X_{t_{i+1}}\big)\cdot \nabla f\big(X_{t_{i+1}}\big)\Big) \\
& + \frac{\varepsilon}{2}\Big(P\big(x_{t_i}\big) + P\big(X_{t_{i+1}}\big)\Big)\cdot\Big(B_{t_{i+1}} - B_{t_i}\Big)
\end{aligned}
\tag{9}
$$

Equation (9) is an implicit equation for the random variable $x_{t_{i+1}}$. An approximation $y_{t_{i+1}}$ for a realization of the random variable $X_{t_{i+1}}$ can be determined therefrom with the aid of the Newton method.

The point $y_{t_{i+1}}$ is impermissible in some circumstances. With the aid of a Newton method, the corrector is now used to determine a point $x_{t_{i+1}}$ in the vicinity of the point $y_{t_{i+1}}$ which is permissible and serves as starting value for a subsequent iteration step.

Another refinement ~~consists~~ resides in that the design constitutes a new design, an adaptation or a control of the technical system.

For a successful design, values which are efficient in each case are determined for the parameter vector and the working point. An efficient valuation of the parameter vector means that no parameter can be changed without thereby worsening a Q factor of the target function.

A technical system can be a process engineering installation or other system which is to be designed or adjusted with reference to various parameters. In particular, the parameters of the parameter vector can be design parameters or operating parameters of the technical system. Operating parameters characterize possible adjustable variables, whereas design parameters describe, in particular, physical dimensions of the technical system and can be adapted or varied during operation mostly only with a high outlay.

The method described can optionally be used to redesign the technical system or to adapt an already existing technical system. In both cases,

this is a design (once as regeneration and once as adaptation) within the meaning of the present discussion.

The technical system is realized or adjusted with the aid of the determined parameters within the scope of a further refinement. It is advantageous in this case that the parameters in a parameter vector which have been determined by ~~means of~~ the invention characterize a stable operating point, and that the adjustment of the system to this operating point ensures long-term reliable operation of the system/installation.

~~In order~~ To better achieve the object, moreover, an arrangement is specified for designing a technical system in the case of which a processor unit is provided which is set up in such a way that

a) the technical system comprises a target function which can be influenced by a parameter vector having n parameters;
b) secondary conditions are prescribed with the aid of which a domain for valid working points of the technical system can be determined;
c) a Stratonovich equation is determined by means of a projection operator;
d) the Stratonovich equation can be solved numerically and an efficient working point can be determined thereby;
e) the efficient working point can be used to design the technical system.

This arrangement is particularly suitable for carrying out the method according to the invention or one of its developments explained above.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the invention are set forth and explained below with the aid of the drawing,

in which:

figure 1 shows a sequence of operations of a method for designing a technical system;

figure 2 shows a sketch which illustrates a numerical solution of a Stratonovich differential equation;

figure 3 shows a sketch which illustrates a projection method;

figure 4 shows a processor unit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 shows a block diagram which illustrates the sequence of operations of a method for designing a technical system. A target function and associated secondary conditions are provided ~~given~~ in a block 101. The secondary conditions limit a space, which is determined by the number of the n parameters of the parameter vector, to a domain as part of this space. An efficient working point from this domain is determined as parameter vector by setting up and solving a Stratonovich equation by using projection operators which take account of the secondary conditions (compare blocks 102 and 103). Some of the working points found serve as starting points for a local search which, in turn, delivers an optimum point (efficient working point) (see block 104). In particular, the numerical solution to the Stratonovich equation includes ~~comprises~~ a predictor-corrector method.

Figure 2 illustrates the predictor-corrector method. Starting from a point x_{t_i} which is located in the permissible working range L, a point $y_{t_{i+1}}$ is

determined ~~(~~, for example, application of the Newton method to equation (9)~~)~~ which is no longer situated in the permissible range L (predictor step 201). In order to transfer the point $y_{t_{i+1}}$ into the permissible range again,

a correction step 202 is determined which leads to the point $x_{t_{i+1}}$.

The interplay between predictor and corrector is repeated iteratively with a constant, decreasing or increasing step size. It may be noted in this case that the line 201 does not necessarily run tangentially.

Figure 3 illustrates the projection method. Once again, the permissible range L is specified on which the point $x_{t_{i+1}}$ is located. The line 203 characterizes an ascending direction $F(X_t)$, and a line 204 indicates a projected ascending direction $P(X_t) \cdot F(X_t)$.

An example ~~A~~ processor unit PRZE is illustrated in **Figure 4**. The processor unit PRZE includes ~~comprises~~ a processor CPU, a memory MEM ~~SPE~~ and an input/output interface IOS, which is used via an interface IFC in different ways: via a graphics interface, an output is visualized on a monitor MON and/or output on a printer PRT and/or output to any other type of output device. An input is performed via a mouse MAS and/ ~~or~~ or a keyboard TAST and/or any other type of input device. The processor unit PRZE also includes ~~has~~ a data bus BUS which ensures the connection of a memory MEM, the processor CPU and the input/output interface IOS. Additional components, for example an additional memory, data memory (hard disk), ~~or~~ scanner, etc. can also be connected to the data bus BUS.

VARIATIONS

List of references, the entire contents of each of which is hereby incorporated herein by reference:

[1] K. Ritter, S. Schäffler: "A Stochastic Method for Constrained Global Optimization", SIAM J. Optimization, Vol. 4, No. 4, pp. 894-904, 1994.

[2] D.G. Luenberger: "Linear and Nonlinear Programming", Addison-Wesley Publishing Company, Massachusetts, pp. 334-337.

[3] P. Protter: "Stochastic Integration and Differential Equations - A New Approach", Springer Verlag, New York, pp. 215-235.

[4] J. Stoer: "Numerische Mathematik 1" ["Numerical Mathematics 1"], Springer-Verlag, Berlin, Heidelberg, 1994, pp. 138-144.

[5] S. Schäffer: "Global Optimization Using Stochastic Integration"; Theorie und Forschung, Vol. 340: Mathematik, Vol. 3; Regensburg: Roderer, 1994; ISBN 3-89073-0; pp. 19-29.

What is claimed is:

~~Patent Claims~~

1. (Amended) A method for designing a technical system, comprising:
   [a) in which the technical system comprises] providing a target function [which is] of the technical system ~~influenced~~ by a parameter vector [having] including a plurality of [n] parameters; of the technical system
   [b) in which] providing secondary conditions [are prescribed with the aid of which] to determine a ~~domain~~ for valid working points of the technical system [is determined];
   [c) in which] determining a Stratonovich equation [is determined by means of] using [a] projection operator;
   [d) in which] solving the Stratonovich equation [is solved numerically, and] thereby determining an efficient working point [is thereby determined]; and
   [e) in which] using the determined efficient working point [is used] to design the technical system.

2. (Amended) The method as claimed in claim 1, [in which] wherein the Stratonovich equation is determined [in] such [a way] that its solution varies in [the] a domain of [the] valid working points.

3. (Amended) The method as claimed in claim 1 [or 2], [in which] wherein the Stratonovich equation is solved numerically by [means of] a predictor-corrector method.

4. (Amended) The method as claimed in claim 3, [in which] wherein the predictor is determined with the aid of [the] a trapezium rule.

5. (Amended) The method as claimed in claim 3 [or 4], [in which] wherein the corrector is determined by [means of the] a Newton method.

6. (Amended) The method as claimed in ~~one of the preceding claims~~ claim 1, ~~in which~~ further comprising: ~~step size control is additionally performed~~ additionally performing step size control.

7. (Amended) The performance of the method as claimed in claim 6, [in which] wherein the step size control [is performed in such a way] includes at least one of,

[a) that] carrying out a step size reduction [is carried out] if a sufficiently large approximation error is determined, [or] and

[b) that] carrying out a step size enlargement [is carried out] if a sufficiently small approximation error is determined.

8. (Amended) The method as claimed in claim 1 [one of the preceding claims], [in which] wherein the Stratonovich equation has the following form:

$$X_t = X_a - \int_a^t P(X_s) \cdot F(X_s) \cdot ds + Z, \text{ [with] wherein } t \geq a \text{ and } X_a = x_0$$

[where] and wherein,

a	denotes a starting instant ($a \geq 0$),
x_0	denotes a permissible starting parameter vector,
X_t	denotes a solution parameter vector at the instant t,
$P(X_s)$	denotes a projection matrix in the parameter vector X_s,
$F(X_s)$	denotes an ascending direction, and
Z	denotes a random variable.

9. (Amended) The method as claimed in claim 8 [9], [in which] wherein the ascending direction is determined by:

$$F = \nabla f(X_s),$$

wherein f [denoting] denotes the target function.

10. (Amended) The method as claimed in claim 8 [or 9], [in which] wherein the random variable is determined by

$$Z = \varepsilon \cdot \int_a^t P(X_s) \circ dB_s ;$$

[where] wherein

ε denotes a scaling factor, and

$\{B_s\colon s \geq a\}$ denotes an n-dimensional Brownian movement.

(Amended)
11. The method as claimed in further comprising: a using [one of the preceding claims] claim 1, [in which] the determined working point [is used] as a starting point for a local optimization method.

(Amended)
12. The method as claimed in further comprising: a transforming [one of the preceding claims] claim 1, [in which] a secondary condition which is present in the form of an inequality [is transformed] into an equation [by means of] using a slack variable s.

(Amended)
13. The method as claimed in claim 12, [in which] wherein the secondary condition $h_i(x)$, which is present in the form of the inequality $h_i(x) \leq 0$, is formulated as

$$\tilde{h}_i(x, s) = h_i(x) + g(s),$$

[where] wherein,

$g(s)$ denotes a function [having] including a value range of all real values greater than or equal to zero,

s denotes the slack variable, and

$h_i(x)$ denotes a secondary condition $h_i(x) \leq 0$.

(Amended)
14. The method as claimed in claim 13, [in which] WHEREIN the function $g(s)$ is determined as

$g(s) = s^2$.

15. (Amended) The method as claimed in [one of the preceding claims] claim, [in which] wherein the design [constitutes] is at least one of ~~a new~~ design, an adaptation [or] and a control of the technical system.

16. (Amended) An arrangement for designing a technical system, comprising: [in which] a processor unit [is provided which is] set up [in such a way that] to perform ~~the steps~~ various steps wherein,

[a)] the technical system [comprises] includes a target function which can be influenced by a parameter vector [having n] including a plurality of parameters[;] and

[b)] [secondary conditions [are prescribed with the aid of which] of the technical system are used to determine a domain for valid working points of the technical system [can be determined;], the processor unit being set up to ~~the steps~~

[c)] determine ~~a~~ Stratonovich equation [is determined by means of] using a projection operator;

[d)] solve ~~the~~ Stratonovich equation [can be solved] numerically and thereby determine ~~an efficient~~ working point [can be determined thereby]; and

[e)] we determined ~~the~~ efficient working point [can be used] to design the technical system.

NEW

17. The method of claim 1, wherein the secondary condition are associated with the target function.

18. The arrangement of claim 16, wherein the secondary conditions are associated with the target function.

19. same as 3, but dep on 2
20. same as 5, but dep on 4
21. same as 6, but dep on 2
22. same as 7, but dep on 21
23. same as 8, but dep on 2
24. same as 9, but dep on 23
25. same as 10, but dep on 9
26. " 10 " 23
27. " 10 " 24
28. " 11 " 2
29. " 12 " 2
30. " 13 " 29
31. " 14 " 30
32. " 15 " 2

33. The arrangement of claim 16, wherein the processor unit ~~further~~ ~~comprising~~ includes a central processor; a memory; and an input and output unit.

34. Same as 2, but change "method" to "arrangement" & dep on cl. 16

35. Same as 3, but change "method" to "arrangement" + dep on cl. 16

36. Same as 4, but change "method" to "arrangement" + dep on cl. 35

37. Same as 8, but change "method" to "arrangement" + dep on cl. 16

38. Same as 9, but change "method" to "arrangement" + dep on 37.

39. " 10 " + dep on 37

40. " 15 " dep on 16

41. The method of claim 1, wherein the projection operator takes account of the secondary conditions.

42. Same as 41, but dep on cl. 17.

43. Same as 41, but "arrangement" for "method" & dep on 16

44. Same as 43, but on 18.

45. The method of claim 1, wherein the efficient working point is an optimum working point.

46. Same as 45, but "arrangement" for "method" + dep on 16.

GR 99 P 1730 MARKED-UP VERSION OF [illegible]

Abstract

Method and arrangement for designing a technical system

A method for designing a technical system is specified in the case of which the technical system ~~comprises~~ includes a target function which is influenced by a parameter vector having n parameters. Furthermore, secondary conditions are prescribed with the aid of which a domain for valid working points of the technical system is determined. An efficient working point is determined ~~by means of~~ using a Stratonovich equation and is used to design the technical system.

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21PRTS

Description

Method and arrangement for designing a technical system

The invention relates to a method and an arrangement for designing a technical system.

In order to design a complex technical system, it is necessary to determine among a set of permissible working points (operating points, design parameters) at least one working point which permits effective running of the system. This frequently requires taking account of secondary conditions which limit the set of working points and therefore also need to be taken into account when searching for the working point.

In practice, the technical system is frequently designed with the aid of experience and the knowledge or one (or more) expert. It is disadvantageous in this case that the probability of error in the case of manual design rises when a certain complexity of the technical system is exceeded.

A method for optimization which follows an approach with the aid of which global optimization is carried out on the basis of a numerical solution of a stochastic differential equation is known from [1]. Secondary conditions are taken into account in this case as penalty functions. It is disadvantageous in this case that the range of permissible working points is left because

a) information is thereby lost,
b) permissibility is frequently more important than quality in a technical system, or it is not even possible to operate the system in an impermissible range, and
c) penalty functions are difficult to prescribe or to dimension in practical use.

[2] describes a method for local optimization under secondary conditions with the aid of projections, in the case of which nonlinear secondary conditions, in particular, are taken into account.

The concept of a Stratonovich equation (also: "Fisk-Stratonovich equation") is known from [3]. In this case, the Stratonovich equation denotes a type of stochastic differential equations with specific (see [3]) properties.

The **object** of the invention consists in permitting a design of a technical system which manages without separate penalty functions.

This object is achieved in accordance with the features of the independent patent claims. Developments of the invention follow from the dependent claims.

In order to achieve the object, a method for designing a technical system is specified in which the technical system comprises a target function which is influenced by a parameter vector having n parameters. Secondary conditions are prescribed with the aid of which a domain for valid working points of the technical system is determined. A projection operator is used to determine a Stratonovich equation which is solved numerically to determine an efficient working point. The determined efficient working point is used to design the technical system.

As a development, the Stratonovich equation is determined in such a way that its solution varies in the domain of the valid working points.

Another development consists in that the Stratonovich equation is solved numerically by means of a predictor-corrector method. A predictor can generally be described

as a prediction variable which has relative to the variable to be predicted an error which is largely compensated by means of the corrector.

In particular, the predictor can be determined with the aid of the trapezium rule. In this context, the trapezium rule for Riemann integrals is known, for example, from [4]. The trapezium rule for Stratonovich integrals follows from the definition of the Stratonovich integral itself. Thus, the Stratonovich integral is defined as a limiting value of the trapezium sums, and so the trapezium rule is a part of the definition of the Stratonovich integral. Trapezium sums are used to set up for the predictor an implicit equation which is solved approximately with the aid of a Newton method.

One refinement consists in that step size control is additionally performed in the course of the global optimization. This takes place, in particular, by means of step size reduction if an excessively large approximation error is expected (value for the expected approximation error exceeds a prescribed bound), or by means of step size enlargement if a (very) small approximation error is expected (value for the expected approximation error is below a prescribed bound).

It is also possible to carry out an additional step size reduction if an efficient working point determined using the above described method is used as a starting value for a subsequent local optimization method. It can be ensured thereby that an approximation with an increasingly smaller step size is performed in the vicinity of the local optimum, and the optimum is achieved with high accuracy thereby.

Another refinement consists in that the Stratonovich equation has the following form, in particular:

$$X_t = X_a - \int_a^t P(X_s)\cdot F(X_s)\cdot ds + Z \qquad (1)$$

with $t \geq a$ and $X_a = x_o$

where

- a denotes a starting instant $(a \geq 0)$,
- x_0 denotes a permissible starting parameter vector,
- X_t denotes a solution parameter vector at the instant t,
- $P(X_s)$ denotes a projection matrix in the parameter vector X_s,
- $F(X_s)$ denotes an ascending direction in the parameter vector X_s,
- Z denotes a random variable.

Furthermore, the ascending direction can be determined by

$$F = \nabla f(X_s), \qquad (2),$$

where f denotes the target function.

In an additional refinement, the random variable Z is determined by

$$Z = \varepsilon \cdot \int_a^t P(X_s) \circ dB_s \qquad (3),$$

where

ε denotes a scaling factor, and

$\{B_s: s \geq a\}$ denotes an n-dimensional Brownian movement.

It is known from [5] that a numerical solution of the stochastic differential equation

$$X_t = X_a \int_a^t \nabla f(X_s) ds + \varepsilon \cdot \int_a^t dB_s, \; t \geq a \qquad (4)$$

with an arbitrary starting parameter vector $x_0 \varepsilon \mathbf{R}^n$ (with **R** as the set of real numbers) and the starting condition $X_a = x_o$ resulting therefrom constitutes a method for global optimization of f in the parameter space.

If, in addition, secondary conditions are present in the form of equations and inequalities which limit the parameter space, the permissible parameter space is, in particular, initially reformulated, by means of introducing slack variables, such that it describes a manifold. In the above differential equation (4), it is only those components of the integrand which run tangential to the manifold that are taken into account. This is performed by multiplying by projection matrices. The result is the particular stochastic differential equation according to equation (1) (in particular seen in conjunction with equations (2) and (3), which is of the type of a Stratonovich differential equation.

An additional development consists in that a secondary condition $h_i(x) \leq 0$ which is present in the form of an inequality is transformed into an equation by means of a slack variable. This transformation has the form, in particular, of

$$\tilde{h}_i(x, s) = h_i(x) + g(s),$$

where

$g(s)$ denotes a function having a value range of all real values greater than or equal to zero (R_0^+),

s denotes the slack variable, and

$h_i(x$ denotes a secondary condition $h_i(x) \leq 0$.

Furthermore, the function $g(s)$ can be determined as:

$$g(s) = s^2 \qquad (6).$$

The solution of the equation (1) constitutes a stochastic process

$$\{X_t : t \geq a\} \tag{7}$$

A sequence of permissible parameter vectors

$$x_{t_1}, x_{t_2}, x_{t_3}, \ldots \quad (a < t_1 < t_2 < t_3 \ldots) \tag{8}$$

is calculated which approximately represent points of a path of the stochastic process in accordance with the equation (7) at the instances t_1, t_2, t_3, ... An iteration step comes about in this case in the following way: let the parameter vectors $x_{t_1}, x_{t_2}, x_{t_3}, \ldots, x_{t_i}$ be already calculated, in which case x_{t_i} then serves as starting point for the Stratonovich equation (1), that is to say $a := t_i$. A parameter vector $x_{t_{i+1}}$ is calculated as a numerical approximation of a point on the path of the solution in accordance with equation (7), which already includes the points $x_{t_1}, x_{t_2}, x_{t_3}, \ldots, x_{t_i}$. The calculation is performed at the instant t_{i+1}, that is to say $t = t_{i+1}$, and the size of the iteration step is yielded as $t_{i+1} - t_i$.

A subset of the sequence (8), in particular that with the smallest target function values, serves the purpose of determining the starting points for a subsequent local search for the optimum.

The approximation of the Stratonovich equation (1) is performed for the (i+1)th iteration step using the following rule (with the aid of the trapezium rule):

$$x_{t_{i+1}} \approx x_{t_i} - \frac{t_{i+1} - t_i}{2}\left(P\left(x_{t_i}\right) \cdot \nabla f\left(x_{t_i}\right) + P\left(x_{t_{i+1}}\right) \cdot \nabla f\left(x_{t_{i+1}}\right)\right) + \frac{\varepsilon}{2}\left(P\left(x_{t_i}\right) + P\left(x_{t_{i+1}}\right)\right) \cdot \left(B_{t_{i+1}} - B_{t_i}\right) \tag{9}$$

Equation (9) is an implicit equation for the random variable $x_{t_{i+1}}$. An approximation $y_{t_{i+1}}$ for a realization of the random variable $x_{t_{i+1}}$ can be determined therefrom with the aid of the Newton method.

The point $y_{t_{i+1}}$ is impermissible in some circumstances. With the aid of a Newton method, the corrector is now used to determine a point $x_{t_{i+1}}$ in the vicinity of the point $y_{t_{i+1}}$ which is permissible and serves as starting value for a subsequent iteration step.

Another refinement consists in that the design constitutes a new design, an adaptation or a control of the technical system.

For a successful design, values which are efficient in each case are determined for the parameter vector and the working point. An efficient valuation of the parameter vector means that no parameter can be changed without thereby worsening a Q factor of the target function.

A technical system can be a process engineering installation or other system which is to be designed or adjusted with reference to various parameters. In particular, the parameters of the parameter vector can be design parameters or operating parameters of the technical system. Operating parameters characterize possible adjustable variables, whereas design parameters describe, in particular, physical dimensions of the technical system and can be adapted or varied during operation mostly only with a high outlay.

The method described can optionally be used to redesign the technical system or to adapt an already existing technical system. In both cases,

this is a design (once as regeneration and once as adaptation) within the meaning of the present discussion.

The technical system is realized or adjusted with the aid of the determined parameters within the scope of a further refinement. It is advantageous in this case that the parameters in a parameter vector which have been determined by means of the invention characterize a stable operating point, and that the adjustment of the system to this operating point ensures long-term reliable operation of the system/installation.

In order to achieve the object, moreover, an arrangement is specified for designing a technical system in the case of which a processor unit is provided which is set up in such a way that

a) the technical system comprises a target function which can be influenced by a parameter vector having n parameters;
b) secondary conditions are prescribed with the aid of which a domain for valid working points of the technical system can be determined;
c) a Stratonovich equation is determined by means of a projection operator;
d) the Stratonovich equation can be solved numerically and an efficient working point can be determined thereby;
e) the efficient working point can be used to design the technical system.

This arrangement is particularly suitable for carrying out the method according to the invention or one of its developments explained above.

Exemplary embodiments of the invention are set forth and explained below with the aid of the drawing,

in which:

figure 1 shows a sequence of operations of a method for designing a technical system;

figure 2 shows a sketch which illustrates a numerical solution of a Stratonovich differential equation;

figure 3 shows a sketch which illustrates a projection method;

figure 4 shows a processor unit.

Figure 1 shows a block diagram which illustrates the sequence of operations of a method for designing a technical system. A target function and associated secondary conditions are given in a block 101. The secondary conditions limit a space, which is determined by the number of the n parameters of the parameter vector, to a domain as part of this space. An efficient working point from this domain is determined as parameter vector by setting up and solving a Stratonovich equation by using projection operators which take account of the secondary conditions (compare blocks 102 and 103). Some of the working points found serve as starting points for a local search which, in turn, delivers an optimum point (efficient working point) (see block 104). In particular, the numerical solution to the Stratonovich equation comprises a predictor-corrector method.

Figure 2 illustrates the predictor-corrector method. Starting from a point x_{t_i} which is located in the permissible working range L, a point $y_{t_{i+1}}$ is

determined (application of the Newton method to equation (9)) which is no longer situated in the permissible range L (predictor step 201). In order to transfer the point $y_{t_{i+1}}$ into the permissible range again,

a correction step 202 is determined which leads to the point $x_{t_{i+1}}$.

The interplay between predictor and corrector is repeated iteratively with a constant, decreasing or increasing step size. It may be noted in this case that the line 201 does not necessarily run tangentially.

Figure 3 illustrates the projection method. Once again, the permissible range L is specified on which the point $x_{t_{i+1}}$ is located. The line 203 characterizes an ascending direction $F(X_t)$, and a line 204 indicates a projected ascending direction $P(X_t) \cdot F(X_t)$.

A processor unit PRZE is illustrated in **Figure 4**. The processor unit PRZE comprises a processor CPU, a memory SPE and an input/output interface IOS, which is used via an interface IFC in different ways: via a graphics interface, an output is visualized on a monitor MON and/or output on a printer PRT. An input is performed via a mouse MAS or a keyboard TAST. The processor unit PRZE also has a data bus BUS which ensures the connection of a memory MEM, the processor CPU and the input/output interface IOS. Additional components, for example an additional memory, data memory (hard disk) or scanner can also be connected to the data bus BUS.

List of references:

[1] K. Ritter, S. Schäffler: "A Stochastic Method for Constrained Global Optimization", SIAM 3. Optimization, Vol. 4, No. 4, pp. 894-904, 1994.

[2] D.G. Luenberger: "Linear and Nonlinear Programming", Addison-Wesley Publishing Company, Massachusetts, pp. 334-337.

[3] P. Protter: "Stochastic Integration and Differential Equations - A New Approach", Springer Verlag, New York, pp. 215-235.

[4] J. Stoer: "Numerische Mathematik 1" ["Numerical Mathematics 1"], Springer-Verlag, Berlin, Heidelberg, 1994, pp. 138-144.

[5] S. Schäffer: "Global Optimization Using Stochastic Integration"; Theorie und Forschung, Vol. 340: Mathematik, Vol. 3; Regensburg: Roderer, 1994; ISBN 3-89073-0; pp. 19-29.

Patent Claims

1. A method for designing a technical system,
   a) in which the technical system comprises a target function which is influenced by a parameter vector having n parameters;
   b) in which secondary conditions are prescribed with the aid of which a domain for valid working points of the technical system is determined;
   c) in which a Stratonovich equation is determined by means of a projection operator;
   d) in which the Stratonovich equation is solved numerically and an efficient working point is thereby determined;
   e) in which the efficient working point is used to design the technical system.

2. The method as claimed in claim 1, in which the Stratonovich equation is determined in such a way that its solution varies in the domain of the valid working points.

3. The method as claimed in claim 1 or 2, in which the Stratonovich equation is solved numerically by means of a predictor-corrector method.

4. The method as claimed in claim 3, in which the predictor is determined with the aid of the trapezium rule.

5. The method as claimed in claim 3 or 4, in which the corrector is determined by means of the Newton method.

6. The method as claimed in one of the preceding claims, in which step size control is additionally performed.

7. The method as claimed in claim 6, in which the step size control is performed in such a way
   a) that a step size reduction is carried out if a sufficiently large approximation error is determined, or
   b) that a step size enlargement is carried out if a sufficiently small approximation error is determined.

8. The method as claimed in one of the preceding claims, in which the Stratonovich equation has the following form:

$$X_t = X_a - \int_a^t P(X_s) \cdot F(X_s) \cdot ds + Z \quad \text{with} \quad t \geq a \text{ and } X_a = x_o$$

where

a denotes a starting instant ($a \geq 0$),

x_0 denotes a permissible starting parameter vector,

X_t denotes a solution parameter vector at the instant t,

$P(X_s)$ denotes a projection matrix in the parameter vector X_s,

$F(X_s)$ denotes an ascending direction, and

Z denotes a random variable.

9. The method as claimed in claim 9, in which the ascending direction is determined by

$$F = \nabla f(X_s),$$

f denoting the target function.

10. The method as claimed in claim 8 or 9, in which the random variable is determined by

$$Z = \varepsilon \cdot \int_a^t P(X_s) \circ dB_s$$

where

ε denotes a scaling factor, and

$\{B_s: s \geq a\}$ denotes an n-dimensional Brownian movement.

11. The method as claimed in one of the preceding claims, in which the determined working point is used as starting point for a local optimization method.

12. The method as claimed in one of the preceding claims, in which a secondary condition which is present in the form of an inequality is transformed into an equation by means of a slack variable s.

13. The method as claimed in claim 12, in which the secondary condition $h_i(x)$, which is present in the form of the inequality $h_i(x) \leq 0$, is formulated as

$$\tilde{h}_i(x, s) = h_i(x) + g(s),$$

where

$g(s)$ denotes a function having a value range of all real values greater than or equal to zero,

s denotes the slack variable, and

$h_i(x)$ denotes a secondary condition $h_i(x) \leq 0$.

14. The method as claimed in claim 13, in which the function $g(s)$ is determined as

$$g(s) = s^2.$$

15. The method as claimed in one of the preceding claims, in which the design constitutes a new design, an adaptation or a control of the technical system.

16. An arrangement for designing a technical system, in which a processor unit is provided which is set up in such a way that

a) the technical system comprises a target function which can be influenced by a parameter vector having n parameters;
b) secondary conditions are prescribed with the aid of which a domain for valid working points of the technical system can be determined;
c) a Stratonovich equation is determined by means of a projection operator;
d) the Stratonovich equation can be solved numerically and an efficient working point can be determined thereby;
e) the efficient working point can be used to design the technical system.

FIG 1

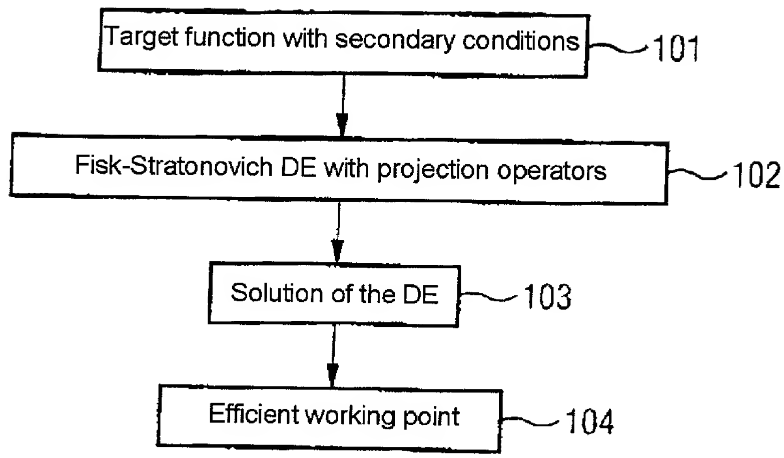

Target function with secondary conditions
101
Fisk-Stratonovich DE with projection operators
102
Solution of the DE
103
Efficient working point
104

FIG 2

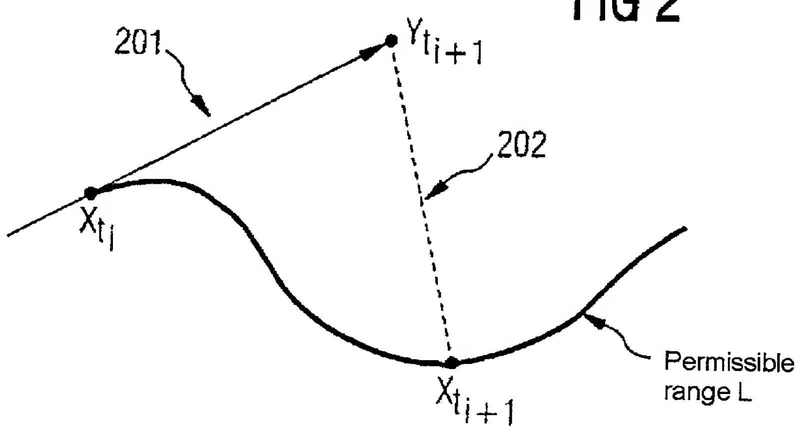

201
$Y_{t_{i+1}}$
202
X_{t_i}
$X_{t_{i+1}}$
Permissible range L

FIG 3

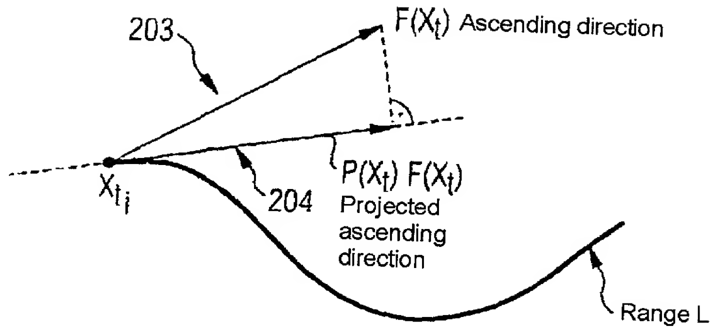
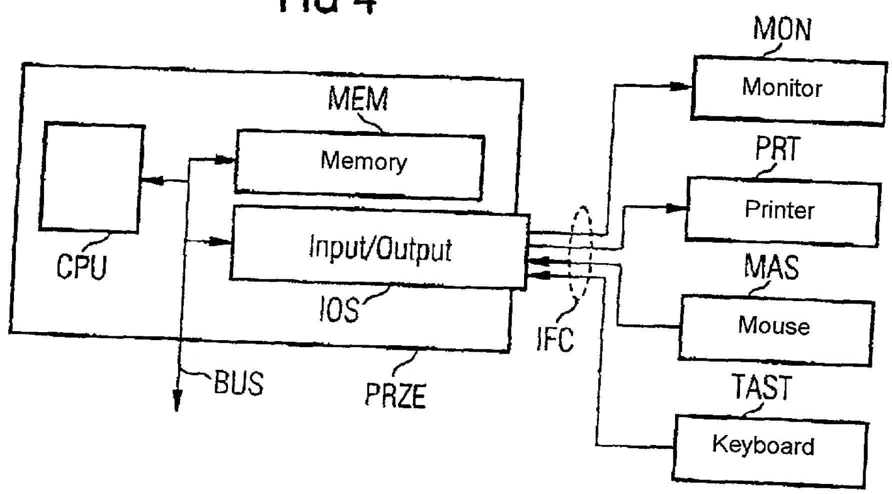

203
F(Xt) Ascending direction
Xti
204
P(Xt) F(Xt)
Projected
ascending
direction
Range L

FIG 4


MON
Monitor
MEM
Memory
PRT
Printer
Input/Output
CPU
MAS
Mouse
IOS
IFC
BUS
PRZE
TAST
Keyboard

PATENT
32860-000191

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.:	**NEW**
Int'l Application No.	PCT/DE00/01035
Filing Date:	October 24, 2001
Applicant:	Annelie STOEHR
Title:	METHOD AND ARRANGEMENT FOR DESIGNING A TECHNICAL SYSTEM

CHANGE OF ADDRESS AND REVOCATION AND SUBSTITUTION OF POWER OF ATTORNEY

Hon. Commissioner of Patents and Trademarks
Washington, D.C. 20231

October 24, 2001

Sir:

Under 37 C.F.R. § 3.73(b), the undersigned hereby states that the below-named Assignee is an assignee in the above-identified Application:

Assignee: **SIEMENS AKTIENGESELLSCHAFT**

The documentary evidence of a chain of title from the original owner to the Assignee is provided in the Assignment Document(s):

☒ filed herewith,

☐ previously filed,

Reel No. _____, Frame No. _____.

I hereby declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements, and the like so made, are punishable by fine or imprisonment, or both, under Section 1001, Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

New U.S. Application No
Docket No. 32860-000191

POWER OF ATTORNEY

The Declaration submitted along with this application includes a Power of Attorney listing the attorneys of Birch, Stewart, Kolasch & Birch, LLP. Please hereby revoke the aforementioned attorneys and substitute the attorneys of Customer No. 30596, including the following attorneys of Harness, Dickey & Pierce, P.L.C., to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

Terry L. Clark	Registration No. 32,644
Donald J. Daley	Registration No. 34,313
John A. Castellano	Registration No. 35,094
Gary D. Yacura	Registration No. 35,416
Thomas S. Auchterlonie	Registration No. 37,275
Timothy R. Wyckoff	Registration No. 46,175

CORRESPONDENCE ADDRESS

I request the Patent and Trademark Office to direct all correspondence and telephone calls relative to this application to Customer No. 30596, Harness, Dickey & Pierce, P.L.C., P.O. Box 8910, Reston, Virginia 20195, (703) 390-3030.

The undersigned is empowered with full Power of Attorney on behalf of the assignee.

Respectfully submitted,

HARNESS, DICKEY & PIERCE, P.L.C

By: [signature]
Donald J. Daley, Reg. No. 34,313

P.O. Box 8910
Reston, Virginia 20195
(703) 390-3030

DJD:kna

Declaration and Power of Attorney For Patent Application
Erklärung Für Patentanmeldungen Mit Vollmacht
German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

dass mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,

dass ich, nach bestem Wissen der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Name angegeben ist) oder ein ursprünglicher, erster und Miterfinder (falls nachstehend mehrere Namen aufgeführt sind) des Gegenstandes bin, für den dieser Antrag gestellt wird und für den ein Patent beantragt wird für die Erfindung mit dem Titel:

Verfahren und Anordnung zum Entwurf eines technischen Systems

deren Beschreibung

(zutreffendes ankreuzen)
☐ hier beigefügt ist.
☒ am 04.04.2000 als
PCT Internationale Anmeldung
PCT Anmeldungsnummer PCT/DE00/01035
eingereicht wurde und am ______
abgeändert wurde (falls tatsächlich abgeändert).

Ich bestätige hiermit, dass ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.

Ich erkenne meine Pflicht zur Offenbarung irgendwelcher Informationen, die für die Prüfung der vorliegenden Anmeldung in Einklang mit Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) von Wichtigkeit sind, an.

Ich beanspruche hiermit ausländische Prioritätsvorteile gemass Abschnitt 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde, und habe auch alle Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird.

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Method and device for developing a technical system

the specification of which

(check one)
☐ is attached hereto.
☒ was filed on 04 04 2000 as
PCT International application
PCT Application No. PCT/DE00/01035
and was amended on ______
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a)

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

German Language Declaration

Prior foreign appplications
Priorität beansprucht

Priority Claimed

19919106.9 (Number) (Nummer)	DE (Country) (Land)	27.04.1999 (Day Month Year Filed) (Tag Monat Jahr eingereicht)	☒ Yes Ja	☐ No Nein
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	☐ Yes Ja	☐ No Nein
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	☐ Yes Ja	☐ No Nein

Ich beanspruche hiermit gemäss Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 122 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind.

I hereby claim the benefit under Title 35. United States Code. §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §122, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occured between the filing date of the prior application and the national or PCT international filing date of this application.

PCT/DE00/01035 (Application Serial No.) (Anmeldeseriennummer)	04.04.2000 (Filing Date D, M, Y) (Anmeldedatum T, M, J)	anhängig (Status) (patentiert, anhängig, aufgegeben)	pending (Status) (patented, pending, abandoned)
(Application Serial No.) (Anmeldeseriennummer)	(Filing Date D.M.Y) (Anmeldedatum T. M. J)	(Status) (patentiert, anhängig, aufgeben)	(Status) (patented, pending, abandoned)

Ich erkläre hiermit, dass alle von mir in der vorliegenden Erklärung gemachten Angaben nach meinem besten Wissen und Gewissen der vollen Wahrheit entsprechen, und dass ich diese eidesstattliche Erklärung in Kenntnis dessen abgebe, dass wissentlich und vorsätzlich falsche Angaben gemäss Paragraph 1001, Absatz 18 der Zivilprozessordnung der Vereinigten Staaten von Amerika mit Geldstrafe belegt und/oder Gefängnis bestraft werden koennen, und dass derartig wissentlich und vorsätzlich falsche Angaben die Gültigkeit der vorliegenden Patentanmeldung oder eines darauf erteilten Patentes gefährden konnen.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

German Language Declaration

VERTRETUNGSVOLLMACHT: Als benannter Erfinder beauftrage ich hiermit den nachstehend benannten Patentanwalt (oder die nachstehend benannten Patentanwälte) und/oder Patent-Agenten mit der Verfolgung der vorliegenden Patentanmeldung sowie mit der Abwicklung aller damit verbundenen Geschäfte vor dem Patent- und Warenzeichenamt: *(Name und Registrationsnummer anführen)*

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith *(list name and registration number)*

And I hereby appoint

Customer No. 02292

Telefongespräche bitte richten an: *(Name und Telefonnummer)*

Direct Telephone Calls to: *(name and telephone number)*

Ext. ____________

Postanschrift:

Send Correspondence to:

Birch, Stewart, Kolasch & Birch, LLP
8110 Gatehouse Road / Suite 500 East 22042 Falls Church, Virginia
Telephone: +1 703 205 8000 and Facsimile +1 703 205 8050
or
Customer No. 02292

Voller Name des einzigen oder ursprünglichen Erfinders: ANNELIE STOEHR	Full name of sole or first inventor ANNELIE STOEHR
Unterschrift des Erfinders: Annelie Stöhr Datum: 17.10.01	Inventor's signature: Annelie Stöhr Date: 17.10.01
Wohnsitz: MUENCHEN, DEUTSCHLAND DE	Residence: MUENCHEN, GERMANY
Staatsangehörigkeit: DE	Citizenship: DE
Postanschrift: HEIDELBERGER STR.12	Post Office Address: HEIDELBERGER STR.12
80804 MUENCHEN	80804 MUENCHEN
Voller Name des zweiten Miterfinders (falls zutreffend):	Full name of second joint inventor, if any:
Unterschrift des Erfinders Datum	Second Inventor's signature Date
Wohnsitz	Residence
Staatsangehörigkeit	Citizenship
Postanschrift	Post Office Address

(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).

(Supply similar information and signature for third and subsequent joint inventors).

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